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Many-body interactions in multiply-charged quantum dots modeled by empirical tight-binding

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March Meeting of the American Physical Society, March 17-22, Indianapolis, IN (2002).

Abstract: Recent STM measurements successfully resolve the richness and complexity of many-body interactions in multiply-charged single quantum dots. Many-body interactions including both direct Coulomb and exchange interactions are calculated with atomistic tight-binding wave functions for InAs spherical quantum dots. In negatively charged quantum dots, sparse electron levels and, consequently, weak Coulomb coupling make it reasonable to treat the many-body interactions as a perturbation. The perturbation treatment successfully identifies the energy spectra of the negatively-charged quantum dots. This agreement verifies our empirical tight-binding model for the electron levels and many-body interactions. In contrast to the simple spectra of the negatively-charged dots, the strong Coulomb coupling between dense and multi-degenerate hole levels leads to complex spectra in positively charged quantum dots. Significant correlation effects in the positively-charged dots are captured by treating many-body interactions with configuration interactions.

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